PLASTIC DEFORMATION AND RECRYSTALLIZATION OF REFACTORY COMPOUNDS

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ABSTRACT. The authors studied the effect of plastic deformation on the properties of refractory compounds. The tests were carried out by the roentgenographic method and measurement of microhardness.

Several theoretical and experimental studies (Ref. 1 -3) have been devoted /13* to investigating the processes occurring in the surface layer of refactory compounds when they are treated on polishing machines and when they are stripped with abrasive disks. Since plastic deformation is one of the most complex physical processes occurring in solid bodies, the nature of this process has still not been adequately explained.

This article investigates the influence of surface cold working upon the properties of the refactory compounds. Cylindrical samples which were prepared by hot pressing from powders of the refactory compounds were studied. Samples with the smallest porosity (2-5%) were selected. The surface cold working of the samples was performed by polishing them on a plane-polishing 3G-71 machine with K316SM1K disks and on a ASO 16-B1-50 polishing machine with the following properties V_{cr} = 35 m/sec, V_{st} = 4 m/min, V_{trans} = 0.6 mm/doub. pass with a polishing depth of 0.03 mm.

The samples were studied by the microhardness method, and by metal and x-ray analyses.

The x-ray photographs were recorded in order to determine the recrystallization temperature in a RKD chamber with a diameter of 57.3 mm. The polished section was arranged at an angle of 20-25° to the incident bundle of x-rays. The x-ray photographs of all the compounds which were studied were recorded, using Cu-K_{α}-radiation. In order to reduce the fog from the secondary characteristic radiation, two films were placed in the chamber, and the second film was employed in the study. Soft radiation was selected -- in order to prevent rays from penetrating to a depth exceeding the thickness of the layer subjected to cold working. The recrystallization temperature was determined from the points on the diffused lines of the x-ray photographs (table).

The refractory compounds were annealed in a vacuum of 10^{-3} mm Hg. The figure presents graphs showing the change in the recrystallization temperature with a change in the duration of isothermal exposures during annealing.

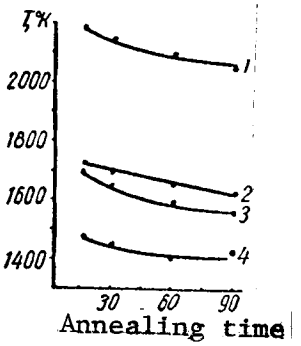
As follows from the data given in the table, the relative recrystallization temperature for borides and carbides is approximately the same. However, /14

* Note: Numbers in the margin indicate pagination in the original foreign text.

CERTAIN CHARACTERISTICS OF RECRYSTALLIZATION PROCESSES FOR HIGH-MELTING COMPOUNDS

Refactory Compound	Microhardness in the Cold-Worked State, dyne/mm^2	Microhardness in the Recrystallized State, dyne/mm^2	T_r °K	T_m °K	T_r/T_m
NbC	2636.2 ± 100	1859 ± 158	2150	4033	0.52
Mo_2C	2403.8 ± 100	1079 ± 30	1450	2838	0.51
WC	2903.9 ± 70	2427.2	1650	3143	0.53
ZrB_2	2784 ± 90	2058.9	1700	3313	0.51

the ratio T_r/T_m is close to 0.5, whereas for metals it is 0.3-0.4 (Ref. 4). This is apparently related to the structural changes in the refactory compounds during deformation, and also to their high combination energy, as compared with more plastic metals and alloys.



Dependence of the Temperature at which Recrystallization of High-Melting Compounds Occurs upon the Annealing Time:

1 - NbC, 2 - ZrB_2,

3 - WC, 4 - Mo_2C

The increase in the relative recrystallization temperature of refactory compounds, as compared with metals, can also be compared with the decrease in the weight of the non-localized portion of the valent metal electrons for compounds of metals with non-metals (Ref. 5). Thus, in the case of niobium carbide, part of the non-localized electrons of the titanium atoms changes into a localized state, participating in the formation of sp^3-hybrid functions of the carbon atom bonds (this change is given in [Ref. 6]). The same situation occurs in the case of molybdenum and tungsten carbides, and also in the case of zirconium diboride.

A decrease in the weight of the non-localized portion of valent electrons, during the formation of compounds of transition metals with non-transition metals, limits the possibility of $s \rightleftarrows d$-exchange and increases the energy which is necessary to excite stable configurations formed by the localized part of valent electrons. This leads to an increase in the ratio T_r/T_m.

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